Effect of Fibre Ash Stabilizer on Volume Reduction of Deltaic Lateritic Soils

Gbinu Samuel Kabari[1], Enamuotor Blessing[2], Charles Kennedy[3],

[1], **School of Engineering, Department of Civil Engineering, Kenule Beeson Saro -Wiwa Polytechnic, Bori, Rivers State, Nigeria.**

[2]**D.G Delta State Direct Labour Agency, Delta State, Nigeria.**

[2]**Faculty of Engineering, Department of Civil Engineering, Rivers State University, Nkpolu, Port Harcourt, Nigeria**

Authors E-mail: [1]kabarisamuel@gmail.com , [2]blesstor2@yahoo.com, [3]ken_charl@yahoo.co.uk.

ABSTRACT

Lateritic Soils of the Deltaic are premature and do not conform to the widely reported parent-rock-related gradation trend common to other lateritic soils and highly deceptive in nature due to their swelling and shrinkage attributes and yet the most widely used road embankment materials within the region. The research work studied the modification of the soils using environmentally friendly agricultural waste products of plantain rachis fibre ash as stabilizer. Preliminary investigations on the geotechnical properties of the soils at natural state classified them as A-2-6 SC and A-2-4 SM on the AASHTO classification schemes / Unified Soil Classification System. Percentage (%) passing BS sieves #200; 38.46%, 39.40%, 36.85%, and 36.42%, reddish brown color, plasticity index of 17.11%, 22.5%, 14.10%, and 18.51%, California bearing ratio (CBR) values unsoaked 9.25%, 9.48%, 7.85% , 8.65 %, and soaked 7.40%, 8.05%, 6.65% and 6.65 % and unconfined compressive strength (UCS) values of 168kPa, 178kPa, 163kPa and 175kPa. These properties do not meet the minimum requirements for soils or soil-based materials usable in road pavement structures as indicated by the Federal ministry of works (FMW) specifications. Comparatively, stabilized soils compaction results showed decreased values of maximum dry density MDD and increased values of optimum moisture content (OMC) with relating values to percentages ratio fibre ash inclusion. Comparative results showed increased values of California bearing ratio (CBR) of unsoaked and soaked with optimum inclusion percentage of 7.5%. Overturned values were notice beyond optimum inclusion which indicated potential failure. Results of unconfined compressive strength (UCS) test on comparison showed corresponding increased to percentages ratio increase of additives to soils. Consistency results showed decreased in plastic index properties parameters corresponding to additives increase percentages ratio.

Key Words: *Lateritic Soils, Plantain Rachis Fibre Ash, CBR, UCS, Consistency, Compaction*

1.0 Introduction

Soils of the Niger Delta are less matured and are derived from much more recent (younger) non-crystalline parent materials commonly known as the coastal plain sand obviously deficient in chemically degradable rock-forming minerals such as feldspars, which are the major contributors to laterization process. They are formed in a plain terrain (characteristic of the Niger Delta region) hence deficient in two of the three necessary and sufficient conditions for full laterization (Little[1]; Tuncer and Lohnes [2]; Blight [3]; Mitchell and Sitar [4]; Townsend [5]).

They can be modified in several ways to suit desired design standard with the addition of various cementitious additives to meet minimum requirements for soils or soil-based materials usable in road pavement structures have been indicated by the FMW Specifications [6].

Charles *et al*. [7] evaluated the engineering properties of soil with the inclusion of costus afer (Bush sugarcane bagasse fiber ash (BSBFA) at varying percentages. Results of compaction of soil between the relationship of optimum moisture content (OMC) and maximum dry density (MDD) of soil and bagasse ash inclusion increased with increase in BSBFA percentages of 7.5% and decreased at 2.5% to 10% bagasse ash inclusion. Stabilization was found to satisfy subgrade requirements. Their results showed the potential of using BSBFA as admixture in soils of clay and laterite. Swelling of treated soil decreased with the inclusion of bagasse fibre ash up to 7.5% for both soils.

Bouhicha *et al*. [8] used the shear box test method to evaluate the strength of compacted earth reinforced with barley straw. Their work was part of a wider study of the physical and mechanical properties of fibre-reinforced compressed earth blocks. Their test results are showed that a 1.5 and 3.5 % (by weight of soil) addition of straw increased the apparent cohesion by up to 50 % (from 330 to 493 kPa), but decreased the angle of internal friction.

Ghavami *et al*.[9] observed that the addition of 4 % coconut and sisal fibres to soil causes its deformability to increase significantly. Besides, the creation of cracks in dry seasons was highly lessened.

Prabakar and Sridhar [10] studied on soil specimens reinforced with sisal fibres showed that both fibre content and aspect ratio have important influences in shear strength parameters.

Charles *et al*. [11] investigated the effectiveness of natural fibre, costus afer bagasse (Bush sugarcane bagasse fibre (BSBF) as soil stabilizer / reinforcement in clay and lateritic soils with fibre inclusion of 0.25%, 0.50%, 0.75% and 1.0%. They concluded that both soils decreased in MDD and OMC with inclusion of fibre percentage, CRB values increased tremendously with optimum values percentage inclusion at 0.75%, beyond this value, crack was formed which resulted to potential failure state.

2.0 Materials and Methods

2.1 Materials

2.1.1 Soil

The soils used for the study were collected from Ogbogoro Town Road, in Obio/Akpor Local Government, Egbeda Town Road, in Emuoha Local Government Area, Igwuruta Town Road, in Ikwerre Local Government Area and Aleto Town Road, in Eleme Local Government area, all in Rivers State, Niger Delta region, Nigeria. It lies on the recent coastal plain of the North-Western of Rivers state of Niger Delta.

2.1.2 Plantain Rachis Fibre Ash

The Plantain Rachis fibres are obtained from Iwofe markets, in Obio/Akpor Local Area of Rivers State, they are abundantly disposed as waste products both on land and in the river.

2.2 Method

2.2.1 Sampling Locality

The soil sample used in this study were collected along Ogbogoro Town, (latitude 4.81° 33‘S and longitude 6.92° 18‘E), Egbeda Town, (latitude 5.14° 15‘N and longitude 6.45° 23‘E), Igwuruta Town, latitude 4.97° 93‘N and longitude 6.99° 80‘E), and Aleto Town, latitude 4.81° 32‘S and longitude 7.09° 28‘E) all in Rivers State, Nigeria.

2.2.2 Test Conducted

Test conducted were (1) Moisture Content Determination (2) Consistency limits test (3) Particle size distribution (sieve analysis) and (4) Standard Proctor Compaction test, California Bearing Ratio test (CBR) and Unconfined compressive strength (UCS) tests;

2.2.3 Moisture Content Determination

The natural moisture content of the soil as obtained from the site was determined in accordance with BS 1377 (1990) Part 2.The sample as freshly collected was crumbled and placed loosely in the containers and the containers with the samples were weighed together to the nearest 0.01g.

2.2.4 Grain Size Analysis (Sieve Analysis)

This test is performed to determine the percentage of different grain sizes contained within a soil. The mechanical or sieve analysis is performed to determine the distribution of the coarser, larger-sized particles.

2.2.5 Consistency Limits

The liquid limit (LL) is arbitrarily defined as the water content, in percent, at which a part of soil in a standard cup and cut by a groove of standard dimensions will flow together at the base of the groove for a distance of 13 mm (1/2in.) when subjected to 25 shocks from the cup being dropped 10 mm in a standard liquid limit apparatus operated at a rate of two shocks per second.

2.2.6 Moisture – Density (Compaction) Test

This laboratory test is performed to determine the relationship between the moisture content and the dry density of a soil for a specified compactive effort.

2.2.7 Unconfined Compression (UC) Test

The unconfined compressive strength is taken as the maximum load attained per unit area, or the load per unit area at 15% axial strain, whichever occurs first during the performance of a test. The primary purpose of this test is to determine the unconfined compressive strength, which is then used to calculate the unconsolidated undrained shear strength of the clay under unconfined conditions

2.2.8 California Bearing Ratio (CBR) Test

The California Bearing Ratio (CBR) test was developed by the California Division of Highways as a method of relegating and evaluating soil- subgrade and base course materials for flexible pavements.

3.0 Results and Discussions

Preliminary results on lateritic soils as seen in detailed test results given in Tables: 5 showed that the physical and engineering properties fall below the minimum requirement for such application and needs stabilization to improve its properties. The soils classified as A-2-6 SC and A-2-4 SM on the AASHTO classification schemes / Unified Soil Classification System as shown in table 3.1 and are less matured in the soils vertical profile and probably much more sensitive to all forms of manipulation that other deltaic lateritic soils are known for (Ola [12]; Allam and Sridharan [13]; Omotosho and Akinmusuru [14]; Omotosho [15]).

The soils are reddish brown and dark grey in colour (from wet to dry states) plasticity index of 17.11%, 22.5%, 14.10%, and 18.51% respectively for Ogbogoro, Egbeda, Igwuruta and Aleto Town Roads. The soil has unsoaked CBR values of 9.25%, 9.48%, 7.85% and 8.65 %, and soaked CBR values of 7.40%, 8.05%, 6.65% and 6.65 %, unconfined compressive strength (UCS) values of 168kPa, 178kPa, 163kPa and 175kPa when compacted with British Standard light (BSL), respectively.

3.1 Compaction Test Results

Investigated results of lateritic soils at 100% of Ogbogoro, Egbeda, Igwuruta and Aleto roads compaction results of maximum dry density (MDD) are 1.755 KN/m^3, 1.838 KN/m^3, 1.924 KN/m^3, 1.865 KN/m^3, and Optimum moisture content(OMC), 14.85%, 14.40%, 15.03% and 16.05%. Fibre ash stabilized soils results maximum values obtained wit 2.5% 5.0%, 7.5% and 10% are MDD, 1.668KN/m^3, 1.768 KN/m^3, 1.792 KN/m^3, 1.805 KN/m^3 and OMC, 16.43%, 17.63%, 15.63% and 16.28%. Comparatively, results showed decreased values of MDD and increased values of OMC with relating values to percentages ratio fibre ash inclusion.

3.2 California Bearing Ratio (CBR) Test

Investigated results at preliminary test at 100% California bearing ratio unsoaked values are 9.25%, 9.48%, 7.85% 8.65 % and soaked values are 7.40%, 8.05%, 6.65% and 6.65 %. Fibre ash modified soils maximum values are unsoaked values are 15.35%, 15.28%, 16.35% 14.80% and soaked values are 13.98%, 14.05%, 15.08% and 13.75% Comparative results showed increased values of California bearing ratio of unsoaked and soaked with optimum inclusion percentage of 7.5%. Overturned values were notice beyond optimum inclusion which signaled potential failure.

3.3 Unconfined Compressive Strength Test

Investigated results at preliminary test at 100% unconfined compressive strength test are 168kPa, 178kPa, 163kPa and 175kPa. Plantain rachis fibre ash modified lateritic soils maximum values are 247kPa, 252kPa, 260kPa and 239kPa. Results of unconfined compressive strength test on comparison showed corresponding increased to percentages ratio increase of additives to soils.

3.4 Consistency Limits Test

Investigated preliminary test of consistency limits (plastic index) at 100% of lateritic soils sampled roads are 17.11 %, 22.50%, 14.1 0% and 18.51%. Fibre ash modified lateritic soils maximum obtained values are 16.08%, 17.63%, 21.36% and 12.87%. Comparative results showed decreased in plastic index properties parameters corresponding to additives increase percentages ratio.

Table 3.1: Engineering Properties of Soil Samples

Location Description	Ogobogoro Road Obio/Akpor L.G.A	Egbeda Road Emuoha L.G.A	Igwuruta Road Ikwere L.G.A	Aleto Road Eleme L.G.A
Depth of sampling (m)	1.5	1.5	1.5	1.5
Percentage(%) passing BS sieve #200	38.35	42.15	36.35	39.40
Colour	Reddish	Reddish	Reddish	Reddish
Specific gravity	2.59	2.78	2.77	15.35
Natural moisture content (%)	22.6	19.48	10.95	15.35
Consistency				
Liquid limit (%)	38.46	42.35	35.15	38.65
Plastic limit (%)	21.35	19.85	21.05	20.14
Plasticity Index	17.11	22.50	14.1 0	18.51
AASHTO soil classification Unified Soil Classification System	A-2-4/SM	A-2-4/SM	A-2-4/SC	A-2-4/SC
Optimum moisture content (%)	14.85	14.40	15.08	16.05
Maximum dry density (kN/m^{3})	1.755	1.883	1.924	1.865
Gravel (%)	3.25	2.85	3.83	2.35
Sand (%)	38.65	36.50	32.58	39.45
Silt (%)	23.85	38.75	33.45	37.85
Clay (%)	34.25	22.90	30.14	20.35
Unconfined compressive strength (kPa)	168	178	163	175
California Bearing Capacity (CBR)				
Unsoaked (%) CBR	9.25	9.48	7.85	8.65
Soaked (%) CBR	7.40	8.05	6.65	6.93

Table 3.2: Results of Subgrade Soil ((Laterite) Test Stabilization Fibre Ash Products at Different Percentages

SAMPLE LOCATION	SOIL + FIBRE PLANTAIN RACHIS ASH	MDD (kN/m^3)	OMC (%)	UNSOAKED CBR (%)	SOAKED CBR (%)	UCS(KPa)	LL(%)	PL(%)	PI(%)	SIEVE #200	AASHTO / USCS (Classification)	NOTES
LATERITE + PLANTAIN RACHIS FIBRE ASH (PRFA)												
OGOBOGORO ROAD OBIO/AKPOR L.G.A	100%	1.755	14.85	9.25	7.40	168	38.46	21.35	17.11	38.46	A–7–4/SM	POOR
	99.75+2.5%	1.764	14.98	10.75	10.07	182	38.24	21.50	16.96	38.46	A–7–4/SM	GOOD
	99.50+5.0%	1.738	15.74	13.60	12.25	213	38.04	21.58	16.45	38.46	A–7– 4/SM	GOOD
	99.25+7.5%	1.693	16.08	15.35	13.98	236	37.86	21.62	16.24	38.64	A –7–4/SM	GOOD
	99.0+10%	1.668	16.43	14.28	12.65	247	37.58	21.73	16.08	38.64	A –7–4/SM	GOOD
ALETO ROAD ELEME L.G.A	100%	1.865	16.05	8.65	6.93	175	38.65	20.14	18.51	39.40	A –7– 4/SC	POOR
	99.75+2.5%	1.828	16.43	10.05	8.35	185	37.93	19.57	18.36	39.40	A –7– 4/SC	GOOD
	99.50+5.0%	1.803	16.85	12.65	10.83	224	37.59	19.56	18.03	39.40	A–7– 4 /SC	GOOD
	99.25+7.5%	1.785	17.27	15.28	14.05	236	37.23	19.36	17.87	39.40	A–7– 4/SC	GOOD
	99.0+10%	1.768	17.63	14.35	12.75	252	36.95	19.32	17.63	39.40	A–7– 4/SC	GOOD
EGBEDA ROAD EMUOHA L.G.A	100%	1.883	14.40	9.48	8.05	178	42.35	19.85	22.50	42.45	A–7– 4/SM	POOR
	99.75+2.5%	1.862	14.72	12.56	10.50	196	42.11	19.90	22.21	42.45	A–7– 4/SM	GOOD
	99.50+5.0%	1.835	14.98	15.28	13.98	218	41.76	19.83	21.93	42.45	A–7– 4/SM	GOOD
	99.25+7.5%	1.805	15.36	16.35	15.08	234	41.88	20.23	21.65	42.45	A–7– 4/SM	GOOD
	99.0+10%	1.792	15.63	14.95	13.87	260	41.09	19.44	21.36	42.45	A–7– 4/SM	GOOD
IGWURUTA ROAD IKWERE L.G.A	100%	1.924	15.08	7.85	6.65	168	35.15	21.05	14.10	36.35	A –7– 4/SC	POOR
	99.75+2.5%	1.903	15.28	8.83	8.05	175	34.83	20.96	13.87	36.35	A –7– 4/SC	POOR
	99.50+5.0%	1.885	15.63	10.85	10.05	208	34.52	20.96	13.56	36.35	A –7– 4/SC	GOOD
	99.25+7.5%	1.842	15.93	14.80	13.75	227	34.18	20.99	13.19	36.35	A–7– 4/SC	GOOD
	99.0+10%	1.805	16.28	13.45	12.88	239	33.85	20.98	12.87	36.35	A–7– 4/SC	GOOD

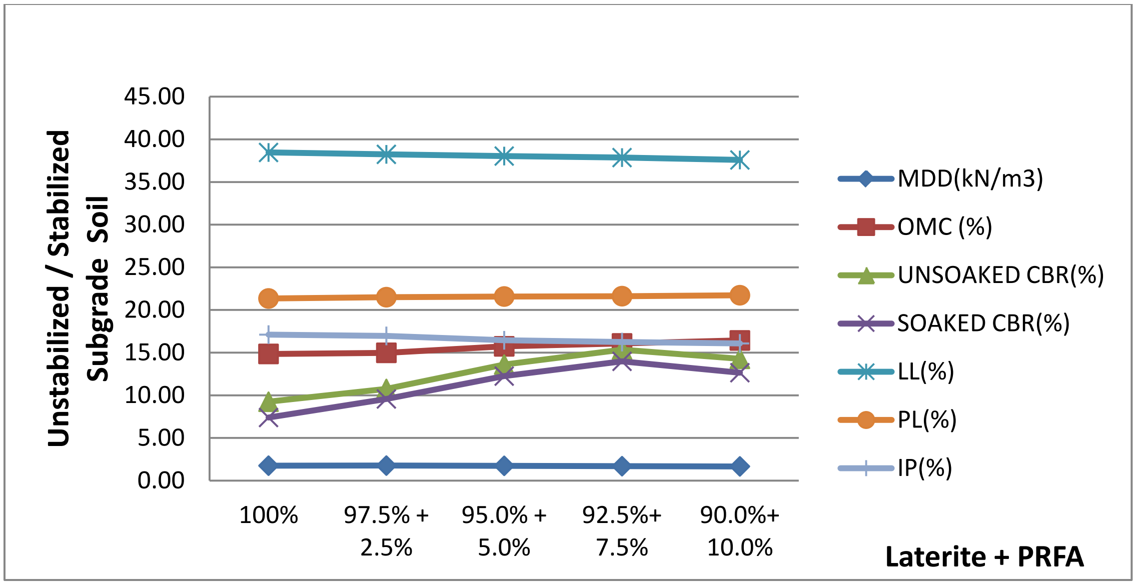

Figure 3.1: Subgrade Stabilization Test of Lateritic Soil from Ogbogoro in Obio/Akpor L.G.A of Rivers State with PRFA at Different Percentages and Combination

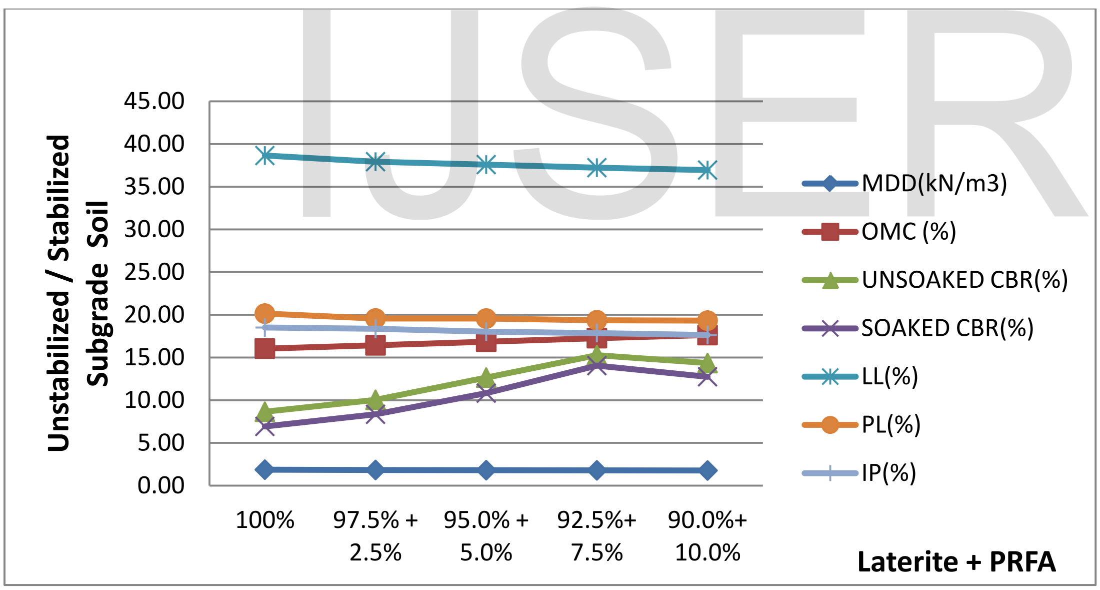

Figure 3.2: Subgrade Stabilization Test of Lateritic Soil from Aleto in Eleme L.G.A of Rivers State with PRFA at Different Percentages and Combination

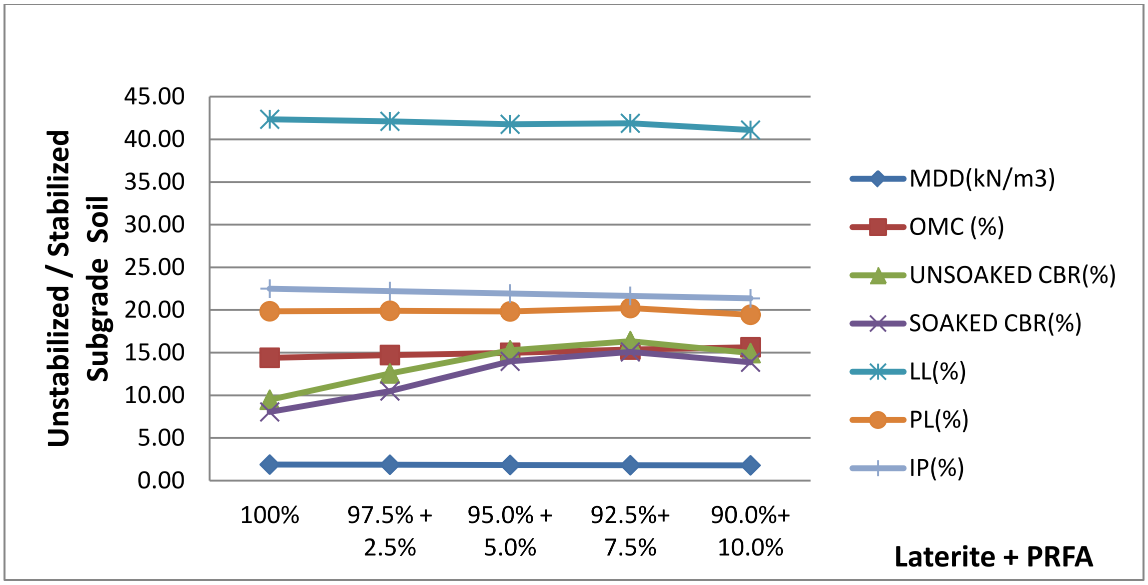

Figure 3.3: Subgrade Stabilization Test of Lateritic Soil from Egbeda in Emuoha L.G.A of Rivers State with PRFA at Different Percentages and Combination

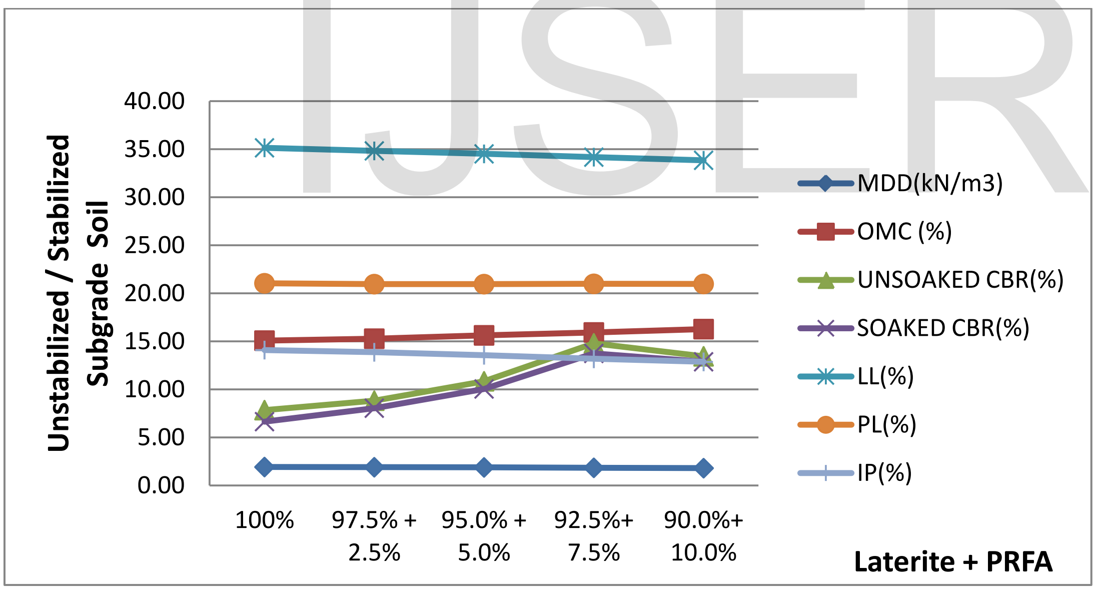

Figure 3.4: Subgrade Stabilization Test of Lateritic Soil from Igwuruta in Ikwerre L.G.A of Rivers State with PRFA at Different Percentages and Combination

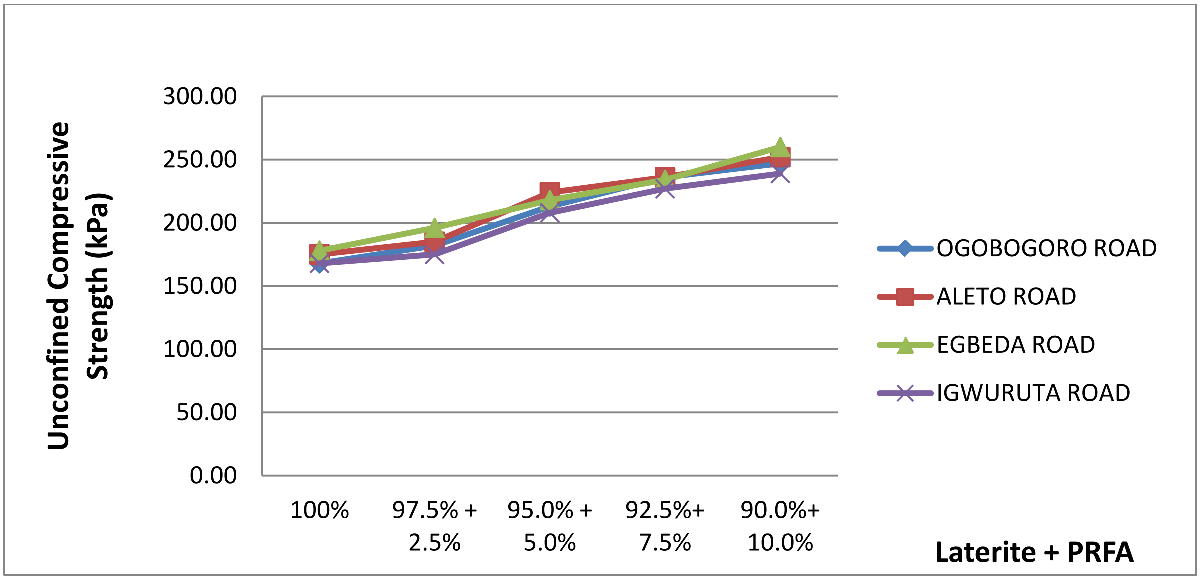

Figure 3.5: Unconfined Compressive Strength (UCS) of Niger Deltaic Laterite Soils Subgrade with PRFA of (Ogbogoro, Aleto, Egbeda andIgwuruta Towns) all in Rivers State

4.0 Conclusions

The following conclusions were made from the experimental research results.

i. Soils are classified as A-2-6 SC and A-2-4 SM on the AASHTO classification schemes / Unified Soil Classification System.

ii. Comparatively, results showed decreased values of MDD and increased values of OMC with relating values to percentages ratio fibre ash inclusion.

iii. Comparative results showed increased values of California bearing ratio of unsoaked and soaked with optimum inclusion percentage of 7.5%. Overturned values were notice beyond optimum inclusion which signaled potential failure.

iv. Results of unconfined compressive strength test on comparison showed corresponding increased to percentages ratio increase of additives to soils.

v. Comparative results showed decreased in plastic index properties parameters corresponding to additives increase percentages ratio.

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